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Production regions, physical and physiological quality of *Brachiaria brizantha* cv. BRS 'Piatã' seeds[1]

Regiões de produção, qualidades física e fisiológica de sementes de *Brachiaria brizantha* cv. BRS 'Piatã'

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ABSTRACT - The quality of seeds is influenced by the climatic conditions of the production field. The identification of characteristics of the best forage seed fields allows the improvement of the sector. In this study, the aim was to identify climatic characteristics of producing regions that may affect the physical and physiological quality of *Brachiaria brizantha* cv. BRS 'Piatã' seeds. Seeds from 10 lots were evaluated for purity, other seeds, mass of a thousand seed, water content, germination, dormancy, emergence, seedling emergence in sand and seedling emergence in the field. Temperature and precipitation data of each production field from flowering to harvest were obtained. The means of treatments were compared by the Scott-Knott test at 5% probability. In order to discriminate which environmental factors influenced seed quality, multivariate statistical analysis was applied through Principal Component Analysis. It was concluded that production fields with temperatures above 30 °C in flowering, threshing and harvesting periods are related to the production of 'Piatã' grass seeds of lower physical and physiological quality. Fields with accumulated rainfall above 500 and 137 mm in the flowering and harvesting period, respectively, are unfavorable to seed vigor.

Key words: Climatic factors. Commercialization of seeds. Tropical forage grasses.

RESUMO - A qualidade das sementes é influenciada pelas condições climáticas do campo de produção. A identificação das características dos melhores campos de sementes de forrageiras permite o aprimoramento do setor. Neste estudo, objetivou-se identificar características climáticas das regiões produtoras que podem afetar as qualidades física e fisiológica de sementes de *Brachiaria brizantha* cv. BRS 'Piatã'. Sementes de 10 lotes foram avaliados quanto à pureza, outras sementes, massa de mil sementes, teor de água, germinação, dormência, emergência, primeira contagem de emergência de plântulas em areia e emergência das plântulas em campo. Foram obtidos os dados de temperatura e precipitação de cada campo de produção desde o florescimento até a colheita. As médias dos tratamentos foram comparadas pelo teste de Scott-Knott, a 5% de probabilidade. Para discriminar quais fatores ambientais influenciaram a qualidade das sementes aplicou-se a análise estatística multivariada através da Análise de Componentes Principais. Concluiu-se que campos de produção com temperaturas acima de 30 °C nas épocas de florescimento, degrana e colheita estão relacionados à produção de sementes de capim-piatã de menor qualidade física e fisiológica. Campos com precipitações pluviométricas acumuladas superiores a 500 e 137 mm no período de florescimento e colheita, respectivamente, são desfavoráveis ao vigor das sementes produzidas.

Palavras-chave: Fatores climáticos. Comercialização de sementes. Gramíneas forrageiras tropicais.

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INTRODUCTION

Among *B. brizantha* cultivars, BRS 'Piatã', launched in 2007 by the Brazilian Agricultural Research Company (EMBRAPA), has been highlighted as an option for the diversification of pasture areas formed with *B. brizantha* cv. Marandú, which occupies approximately 45% of these areas (MONTAGNER *et al*., 2013; QUINTINO *et al*., 2016). Despite the importance of this input, *Brachiaria* spp. seeds have low quality and research in this area is necessary (CARDOSO *et al*., 2014; PEREIRA *et al*., 2011).

Commonly, forage seed production fields are often installed in traditional grazing areas and fields. However, not always the place where a plant adapts well, that is, shows vigorous vegetative growth and better performance as forage is the most suitable for the production of seeds (ARAÚJO; DEMINICIS; CAMPOS, 2008; SOUZA, 2001).

It has been found that for agricultural crops, certain regions are abler to produce seeds and, in other cases, to produce grains (CARVALHO; NAKAGAWA, 2012; LORENTZ; NUNES, 2013). Seeds must have quality characteristics that are not necessary for grains, such as germination, vigor, physical purity and genetics (BRASIL, 2009; CARVALHO; NAKAGAWA, 2012; MARCOS FILHO, 2016).

Thus, in order to be commercialized, seeds must meet State or Federal Quality Standards established for the species (BRASIL, 2008; CARVALHO; NAKAGAWA, 2012). For the approval of a forage seed lot intended for commercialization, the results of germination, tetrazolium and purity tests are usually required. The latter is part of the physical quality assessment and in this determination, there is a maximum permissible limit of wild weed, noxious tolerant and noxious forbidden seeds. The presence of noxious seeds in the lot may impair its commercialization (BRASIL, 2008).

In the internal quality control of seed producing companies, vigor tests are used (MARCOS FILHO, 2016). First count, germination, emergence and seedling emergence in sand tests were recommended for grass seeds (MELO *et al*., 2017; SILVA *et al*., 2017).

Research on *B. brizantha*, *B. humidicola* and *B. decumbens* seeds verified differences in physical and physiological quality of different production regions, but without relating these parameters to the climatic conditions of these fields (LAURA *et al*., 2009).

Thus, for forage grasses, there are no research works, but rather reports on the harmful effect on seed production and quality due to climatic factors such as: strong winds, high temperatures, torrential rains and high relative air humidity (SOUZA, 2001). The present study had as aim to identify climatic characteristics of seed production regions that can affect the physical and physiological qualities of *B. brizantha* cv. BRS 'Piatã' seeds.

MATERIAL AND METHODS

The work was developed with *B. brizantha* cv. BRS 'Piatã' seeds harvested in 10 production fields in several states of Brazil (Table 1).

Rainfall and maximum temperature data during the reproductive cycle of the species, flowering, threshing and harvesting, from December 2014 to July 2015, depending on the production field were obtained from the National Institute of Meteorology (INMET). Seeds were harvested by soil harvester. For this, the plants were cut by a mower blade and putted in line. The harvester swept the soil from the surface mixed with the seeds to the inside, where the material was vented and sifted to remove some of the impurities that were mixed with the seeds. Samples of 5 Kg of each lot of seeds were obtained, homogenized, packaged in paper and sent to the Laboratory of Seed Analysis for quality evaluation tests.

In the laboratory, samples were stored in cold chamber, during three months (9 ± 2 °C and RH 45 ± 5%) to avoid loss of physiological quality during the experimental period. The evaluation of the physiological quality of seeds from each field was performed through tests and determinations described below.

Water content - determined by the greenhouse method at 105 ± 3 °C for 24 h (BRASIL, 2009), with three subsamples of 0.5 grams of seeds.

Physical purity - determined using three subsamples of 10.0 g of seeds weighed on a precision scale (0.001 g). The separation of components was performed with sieves and pneumatic blower and the pure seed portion was obtained by manual separation, the results being expressed as percentage of pure seeds, impurities and other seeds (BRASIL, 2009).

Determination of other seeds by number - in a 100 g sample of seeds weighed on a precision scale (0.001 g) seeds of other species were counted and identified. In the impossibility of identification of the species, only the genus or botanical family of the other seed was reported. The results were presented in number of seeds of each species by the weight of the sample (BRASIL, 2009).

Mass of one thousand seeds - determined using eight subsamples of 100 seeds, removed from the pure

Table 1 - Maximum temperature (T +) and accumulated rainfall (R) at flowering (F), degrane (D) and harvesting (H) periods of *Brachiaria brizantha* cv. BRS ‘Piatâ’ seeds of different production fields

Production fields	F	D	H	T+F	T+D	T+H	RM	RH
				--------------- °C		--------------	-------- mm	--------
Santo Anastácio-SP	Dec-Feb	Feb-Apr	Mar-Jun	32.3	30.6	26.4	826	181
Dracena-SP	Dec-Feb	Feb-Apr	Mar-Jun	33.1	31.5	27.6	928	167
Jataí-GO	Dec-Feb	Feb-Apr	Mar-Jul	31.8	31.0	29.1	1024	137
Palmeiras de Goiás-GO	Jan-Feb	Feb-Apr	Mar-Jun	32.6	30.8	30.0	815	71
São Desidério-BA	Dec-Feb	Feb-Apr	Mar-Jun	32.3	31.8	32.0	903	15
Correntina-BA	Dec-Feb	Feb-Apr	Mar-Jun	32.0	32.0	30.3	709	47
Tupaciguara-MG	Jan-Mar	Feb-Apr	Mar-Jul	29.8	28.7	26.5	762	83
Unaí-MG	Dec-Feb	Feb-Apr	Mar-Jul	32.6	31.5	29.7	914	41
Costa Rica-MS	Dec-Feb	Feb-Mar	Jun-Jul	30.8	29.7	29.1	1126	39
Paraíso das Águas-MS	Dec-Feb	Feb-Mar	Jun-Jul	29.8	28.3	27.1	1011	31

Data provided by the INMET (National Institute of Meteorology), Embrapa and Agritempo - Agrometeorological Monitoring System. M: Maturation; Jan: January; Feb: February; Mar: March; Apr: April; Jun: June; Jul: July

portion and weighed in precision scale (0.001 g), with results expressed in gram (BRASIL, 2009).

Germination - carried out with eight subsamples of 50 seeds, sown on two sheets of filter paper, moistened with distilled water, in an amount equivalent to 2.5 times the mass of the dry substrate, packed in transparent plastic boxes (11.0 x 11.0 x 3.5 cm), maintained at 20-35 °C. Normal seedling counts were performed on the 7th and 21st day after sowing (BRASIL, 2009).

After the end of the germination test, the remaining seeds were submitted to the tetrazolium test to identify dormant and dead seeds. Seeds were sectioned in the medial portion and longitudinally through the embryo and one of the halves was immersed in 0.1% tetrazolium solution at 30 ± 3 °C for two hours in the absence of light (CARDOSO *et al*., 2014). After this period, seeds were washed in distilled water and immediately read as viable (dormant) and non-viable (dead) (BRASIL, 2009).

Seedling emergence in sand - conducted with four subsamples of 50 seeds, which were sown in sand moistened to 60% of the retention capacity of the substrate in water inside plastic boxes (22.0 x 15.0 x 5.0 cm), maintained on a laboratory bench at 26 ± 3 °C. The percentage of seedlings emerged at 21 days after sowing (SILVA *et al*., 2017) was recorded.

First count of seedling emergence in sand - evaluated concurrently with the seedling emergence in sand, but counting emerged seedling seven days after sowing (SILVA *et al*., 2017).

Seedling emergence in the field - conducted by sowing four subsamples of 50 seeds in rows of 1.5 m in length, spaced 0.2 m between rows at a depth of two centimeters in beds in the field in the second fortnight of March. Counts were performed daily until 21 days after sowing and the results were expressed as percentage (SILVA *et al*., 2017). During this period, maximum temperature of 31.4 °C; minimum temperature 20.2 °C; mean relative humidity of 79.3% and rainfall of 132.9 mm were observed, distributed over 17 days. Data were recorded by the Agrometeorological Station of UNESP at Jaboticabal, SP. Irrigation was performed when necessary.

The experimental design was completely randomized, with the exception of seedling emergence in field that was arranged in randomized blocks with four replicates per lot. Data were tested for normality by the Shapiro-Wilk test, homoscedasticity by the Cochran test and submitted to ANOVA.

The statistical procedure was divided into two stages. In the first, univariate statistic was used. For each parameter analyzed, data obtained were analyzed separately by means of analysis of variance and the means of treatments were compared by the Scott Knott test at 5% probability. Parameters of physiological quality of seeds that showed differences among production fields were identified at this stage and these were evaluated in the second stage.

In the latter stage, for the implementation of the multivariate analysis, a maximum of 10 climatic parameters and the physiological quality of seeds that showed differences among production fields were selected. This methodology was recommended by Hongyu, Sandanielo and Oliveira Junior (2015), since the number of variables should not exceed the number of sample units, which would be 10 lots.

In the multivariate statistic, the Principal Component Analysis was adopted using the Statistica software, version 7, after standardization of the null mean and unit variance.

RESULTS AND DISCUSSION

The physical purity of seeds from different production fields ranged from 51.0 to 95.1% (Table 2). Only those produced in São Desidério - BA and Unaí - MG were below 60%, which is the minimum value for commercialization established by the standards of the Ministry of Agriculture for *Brachiaria* (BRASIL, 2008). Thus, based on purity characteristics, most seed lots, even without processing, could be commercialized in the national market, since the minimum purity required by *Brachiaria* Seed Standards is 60% (BRASIL, 2008).

Considering the purity and inert material in seeds from different production fields, the following classification was verified, similar to that was adopted by Silva *et al*. (2019b): seeds from Paraíso das Águas - MS had high quality; Dracena - SP and Tupaciguara - MG had intermediate-high quality; Jataí - GO had intermediate quality; Santo Anastácio - SP, Palmeiras de Goiás - GO and Correntina - BA had intermediate-low quality; Costa Rica - MS had low quality. Seeds from São Desidério - BA and Unaí - MG would be below seed standards (BRASIL, 2008) and would require processing to increase purity to be commercialized, as was verified for *Panicum maximum* seeds (MELO *et al*., 2016a, b).

The physical quality of fresh seeds, newly harvested in the field, is usually related to the conduction of the production field and to the methods and procedures used in harvest (LIMA JÚNIOR *et al*., 2015). Therefore, the purity results obtained may be related to differences in the setting of harvesting machines and pre-cleaning in the field.

The most widely used method for the harvesting of *B. brizantha* seeds is by mechanized soil sweeping (QUADROS *et al*., 2012). However, no studies on the effect of adjusting this type of harvesters on the quality of forage seeds were found.

According to information from the JC Maschietto Company, Paraíso das Águas (MS) growers have stood out from the others over the years due to the higher quality of seeds they produced and must have pre-cleaned in a better way than the others, removing a greater amount of impurities from the seed lot. This type of grower would be ideal, since they always try to produce the best seed and not only seeds within the required standards (TOLEDO, 1977).

Table 2 - Purity, inert material, other seeds and mass of a thousand seeds in the evaluation of the physical quality of 10 lots of *Brachiaria brizantha* cv. BRS 'Piatã' seeds from different production fields

Production fields	Purity	Inert Material	Other Seeds	Mass of a Thousand Seeds g
	%			
Santo Anastácio-SP	73.1 d	26.8 d	0.10 a	9.47 c
Dracena-SP	87.0 b	13.0 b	0.01 a	9.96 b
Jataí-GO	80.7 c	19.3 c	0.00 a	9.56 c
Palmeiras de Goiás-GO	72.4 d	27.6 d	0.02 a	9.15 d
São Desidério-BA	51.3 f	48.7 f	0.00 a	10.01 b
Correntina-BA	73.9 d	26.1 d	0.02 a	10.38 a
Tupaciguara-MG	87.8 b	11.8 b	0.40 b	10.12 b
Unaí-MG	51.0 f	49.0 f	0.01 a	9.56 c
Costa Rica-MS	68.5 e	31.1 e	0.40 b	9.38 c
Paraíso das Águas-MS	95.1 a	4.4 a	0.00 a	10.53 a
F	145.4**	144.9**	11.0**	21.9**
CV (%)	2.8	8.2	85.4	2.8

**Significant at 1% probability by the F test. Means followed by the same letter do not differ from each other by the Scott-Knott test at 5% probability

Regarding the other seeds, weed seeds predominated. The highest percentages of these seeds (0.4%) were found in the lots of Tupaciguara - MG and Costa Rica - MS. Failure to control the weed community results in an increase in the incidence of weed seeds in the lot and highlights the importance of field surveys during the vegetative period for weed control, as prescribed by Seed Standards (BRASIL, 2008).

In the determination of other seeds by number, the presence of seeds of seven weed species was verified: in lots from Santo Anastácio - SP (4 *Ipomoea* sp. seeds), Dracena - SP (2 *Acanthospermum australe* seeds), Palmeiras de Goiás - GO (1 *Croton grandulosus* and 1 *Ipomoea* sp. seeds), Correntina - BA (1 *Apium leptophyllum* seed), Tupaciguara - MG (4 *Ipomoea* sp. seeds), Unaí - MG (1 *Sorghum halepense* seed) and Costa Rica - MS (1 seed of one of each species: *A. leptophyllum*, *Commelina benghalensis*, *Ipomoea* sp. and *Sida cordifolia*). After harvest, Silva *et al*. (2019a) in the evaluation of *Brachiaria decumbens* seeds lots were checked high incidence seeds weeds because of similarity between weeds and forage seeds in terms of size, weight and shape may make it unfeasible to separate them by processing.

It was not possible to attribute the higher incidence of these weeds to the climatic factors of the production regions, since they are cosmopolitan invasive plants, which are distributed throughout the Southeastern, Midwestern and Northeastern states of Brazil (BRAGA *et al*., 2012; DINIZ *et al*., 2017; JAKELAITIS *et al*., 2010).

Of the weed seeds found, *Sorghum halepense* was classified by Brazil (2008) as noxious forbidden. In this way, the lot of seeds of Unaí - MG would be rejected for commercialization. In the other lots, only tolerated noxious weed seeds such as *Ipomoea* sp. and *Sida* sp. were registered, but in amounts below the number prescribed by the Seed Standards (BRASIL, 2008). Therefore, these lots could be marketed. In addition, crude seeds would also be submitted to the beneficiation process, which is able to completely or partially remove weed seeds (CARVALHO; NAGAKAWA, 2012; MELO *et al*., 2016a, b, 2018).

As for the mass of a thousand seeds (Table 2), those from Correntina - BA and Paraíso das Águas - MS presented the highest values of 10.38 and 10.53 g, respectively. The improved pre-cleaning performed in the production field by Paraíso das Águas (MS) growers, which increased the purity of the lot, should also have removed lighter seeds, allowing the maximum values for the mass of one thousand seeds to be obtained. The region of Correntina - BA, on the other hand, as it produced seed of intermediate purity, the high mass of one thousand seeds can be attributed to their filling due to the favorable climatic conditions of the region. In contrast, seeds from Palmeiras de Goiás - GO had the lowest mass of one thousand seeds, 9.15 g.

The environment of the production field, harvesting season and plant nutrition may increase seed mass (CARVALHO; NAKAGAWA, 2012). The influence of climatic conditions on the mass of a thousand seeds was reported by Laura *et al*. (2009), for *B. brizantha*, *B. decumbens* and *B. humidicola*.

The water content of *B. brizantha* cv. BRS ‘Piatã’ seeds from 10 lots ranged from 8.8 to 9.6% (Table 3). These values can be considered similar, because Silva *et al*. (2017) recommended that the differences in water content among of ‘Piatã’ seeds lots to be compared should be less than four percentage points so that the results of vigor and germination tests are reliable.

It was observed that the germination of seeds from different production fields was between 38 and 90%. This large difference confirms reports by Laura *et al*. (2009) that the production field has influence on the quality of forage seeds. Commonly, different lots of *Panicum* sp. and *Brachiaria* sp. seeds have different physical and physiological quality (MELO *et al*., 2016a, b, 2017, 2018; SILVA *et al*., 2017).

According to Normative Instruction No. 30 of the Ministry of Livestock and Supply (MAPA), the minimum germination standard for the commercialization of certified *B. brizantha* seeds is 60% (BRASIL, 2008). Therefore, the germination percentages of lots from Jataí - GO, Palmeiras de Goiás - GO, São Desidério - BA and Costa Rica - MS did not meet the minimum values required (Table 2). Among lots from these fields, that from São Desidério - BA, in addition to germination, also did not meet the physical purity requirement, as previously highlighted.

Seeds from Unaí - MG, even with satisfactory germination (62%), would need the beneficiation process to increase the physical purity percentage to be commercialized (Table 2). The efficiency of the beneficiation process for increasing the purity of lots was confirmed by Melo *et al*. (2016a, b, 2018) for *P. maximum* cv. Mombasa, Tanzania and Massai seeds.

Lots of *B. brizantha* cv. BRS ‘Piatã’ seeds presented dormant seeds in values between 1 and 22%. The municipalities that produced the highest percentage of these seeds were: Jataí - GO and São Desidério - BA, with values of 14 and 22%, respectively. This high percentage should be related to the occurrence of rainfall in the first and second flowering, associated to the greater thermal amplitude verified in both municipalities, with maximum temperatures between 30 and 35 °C and minimum between 10 and 15 °C, respectively (Tables 1 and 2).

Table 3 - Water content (WC), germination (G), dormant seeds (DS), emergence (E) and first count of seedling emergence in sand (FSE) and emergence of seedlings in field (EF) of *Brachiaria brizantha* cv. BRS ‘Piatã’ seeds from different production fields

Production fields	WC	G	DS	E	FSE	EF
	%					
Santo Anastácio-SP	9.2	72 b	2 a	37 c	29 c	64 a
Dracena-SP	9.5	66 c	5 b	36 c	32 c	50 b
Jataí-GO	9.4	59 d	14 c	30 c	28 c	50 b
Palmeiras de Goiás-GO	9.4	55 d	7 b	48 b	43 b	50 b
São Desidério-BA	9.6	38 e	22 d	44 b	30 c	58 a
Correntina-BA	9.5	90 a	1 a	76 a	72 a	63 a
Tupaciguara-MG	9.0	87 a	1 a	50 b	45 b	62 a
Unaí-MG	9.4	62 c	3 a	53 b	40 b	51 b
Costa Rica-MS	8.8	56 d	5 b	45 b	41 b	39 c
Paraíso das Águas-MS	9.6	85 a	1 a	76 a	72 a	67 a
F	-	86.0**	34.2**	40.5**	47.1**	6.9**
CV (%)	-	5.3	40.2	9.9	11.1	12.0

**Significant at 1% probability by the F test. Means followed by the same letter do not differ from each other by the Scott-Knott test at 5% probability

According to Vivian *et al*. (2008), low or high temperatures over a long period of time promote the reduction in the synthesis of phytochrome receptors causing seed dormancy. It is worth mentioning that the seeds evaluated were freshly harvested; came from the field to the laboratory without being stored and, therefore, they were still dormant (CARVALHO; NAKAGAWA, 2012).

The occurrence of dormancy in commercial lots of *Brachiaria* spp. seeds was minimized by the adoption of the soil sweeping method. This harvesting method allows seeds to complete the maturation process and remain on the soil exposed to the environment until they are harvested (MELO *et al*., 2016a, b, 2018; TOMAZ *et al*., 2015). These facts allow us understanding the low dormancy percentage, between 1 and 7% verified in 80% of lots evaluated (Table 3).

The vigor evaluated by the emergence and first count of seedling emergence in sand was between 30 and 76% and between 28 and 72%, respectively. Therefore, higher seed vigor was verified in lots from Correntina - BA and Paraíso das Águas - MS. These lots had also stood out from the others due to the greater amount of reserves evaluated by the mass of a thousand seeds and also the maximum germination (Tables 2 and 3).

The lots of ‘Piatã’ seeds from different production fields presented seedling emergence percentages between 39 and 67%. The field conditions during the test were close to the ideal for the species reported in Brazil (2009), since the average minimum and maximum daily temperatures in the period were 20 and 35 °C, respectively (BRASIL, 2009). This fact may explain the better seed performance in the emergence of seedlings verified in field conditions when compared to laboratory emergence in sand substrate, whose temperature recorded in the period was 26 ± 3 °C.

The storage of seeds in cold and dry chamber for approximately three months, between reception in laboratory and the emergence of seedlings in the field was enough to overcome dormancy of seeds from São Desidério - BA, thus justifying the difference of the greatest emergence of seedlings in the field of seeds from this production field when compared with germination in laboratory. Seed storage after harvest for more than four months allows overcoming natural dormancy (QUADROS *et al*., 2012; TOMAZ *et al*., 2015).

Among parameters of physical and physiological quality of seeds and climatic factors of production fields that were identified as distinct among regions, the ten main variables were chosen in the previous stages of the research. In this way, the correlations between components and the following variables were analyzed: purity, mass of a thousand seeds, germination, seedling emergence in field, seedling emergence in sand, maximum temperature at flowering, threshing and harvesting, accumulated rainfall at flowering and harvesting (Table 4).

Statistical correlation analysis identified two principal components for the interpretation of variability of seed quality and climatic factors data of ‘Piatã’ seeds. Principal components 1 and 2 presented total variance

Table 4 - Correlation of variables with each principal component and variability of seed quality and climatic factors data of 10 lots of *Brachiaria brizantha* seeds

------------------------------------Variables------------------------------		Principal Components	
		1	2
Seeds quality	Purity	-0,76	0,48
	Weight of a thousand seeds	-0,64	-0,33
	Germination	-0,85	0,04
	Seedling emergence in sand	-0,67	-0,71
	Seedling emergence in the field	-0,62	-0,20
Climatic factors	Maximum flowering temperature	0,79	-0,06
	Maximum degrane temperature	0,77	-0,32
	Maximum harvest temperature	0,60	-0,73
	Accumulated rainfall on flowering	0,37	0,60
	Accumulated rainfall on harvest	0,13	0,82
Eigenvalues		4,68	2,54
Total Variance (%)		42,55	23,12
Accumulated Variance		65,67	

of 42.55 and 23.12%, respectively, and the sum of these values totaled 65.67% of accumulated variance.

Therefore, principal components effectively summarized the total sample variance, according to Rencher (2002), that approximately 70% of the total variance must be explained by the principal components. The variance accumulated in this study was close to that found by Silva *et al*. (2017) in a research on vigor tests to evaluate the physiological quality of seeds of this species.

For each of the principal components, all correlation values equal to or greater than 0.6 were considered relevant and with discriminatory power (LORENTZ; NUNES, 2013; SILVA *et al*., 2017). Therefore, in the correlation analysis of principal component 1, it was verified that all variables presented discriminatory power, except the rainfall accumulated in flowering and harvesting, since these presented values of 0.37 and 0.13, respectively.

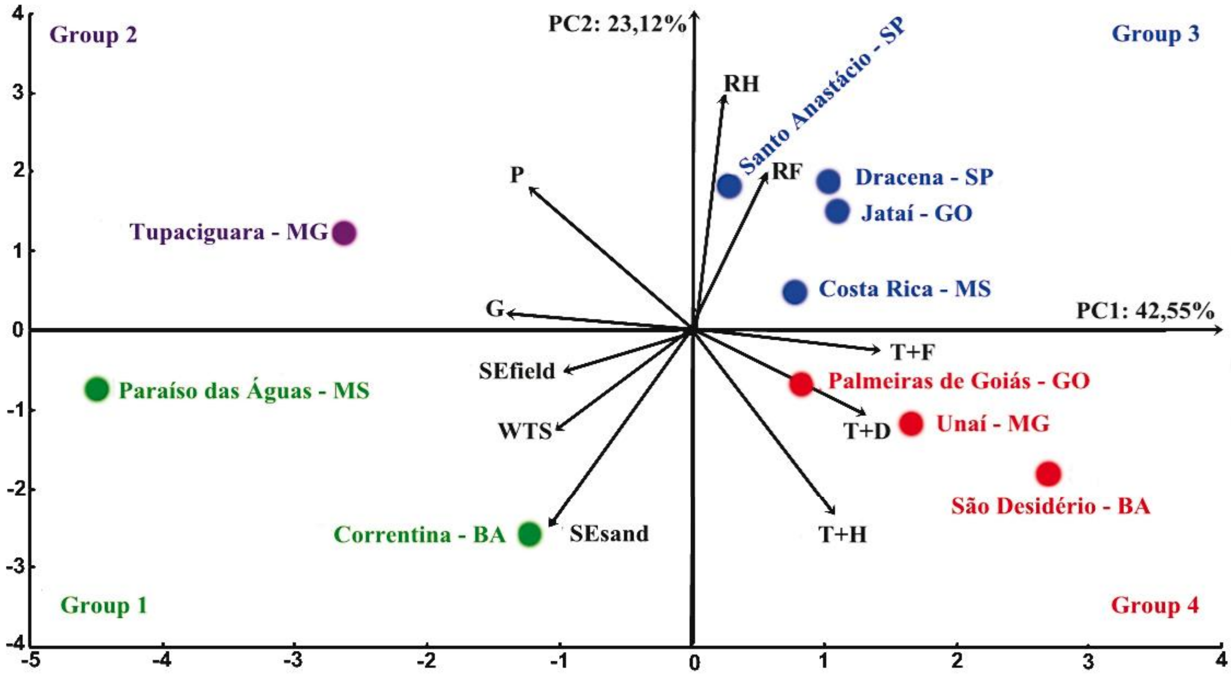
Among physiological quality variables that obtained discriminatory power in principal component 1, the most representative were purity, germination and seedling emergence in sand, as they presented the largest vectors in the dispersion chart (Figure 1). Among the variables of climatic factors, the most representative were maximum temperatures in flowering and threshing, being possible by these variables to classify seed quality levels.

For principal component 2, only seedling emergence in sand, maximum temperature at harvest, accumulated rainfall at flowering and harvesting presented discriminatory power for lots, since they presented values equal to or greater than 0.6 (Table 4). Therefore, these variables presented greater discriminatory power, and can be considered equally representative due to the similar size of vectors, except for accumulated precipitation in flowering, which presented a smaller vector (Figure 1). In a study by Silva *et al*. (2017) on vigor tests for 'Piatã' seeds, seedling emergence in sand test also presented efficiency in the ranking of lots at different physiological quality levels.

Variables seedling emergence in sand and maximum temperature at harvest were the only variables with discriminatory power in both principal components (1 and 2) (Table 4).

In principal component 1, the values of seed quality variables were inversely proportional to those of the climatic variables and this can be verified by the negative and positive values, respectively. This means that temperatures above 30 °C in flowering, threshing and harvesting periods would be related to the production of lower quality seeds, in terms of purity, seed mass, germination, seedling emergence in sand and field. This fact is verified in Table 1, in so that maximum temperatures during the flowering (between December and May), were between 30.2 and 32.4 ºC for the different production sites, except for Tupaciguara - MG and Paraíso das Águas - MS that had maximum temperatures below 29.6 ºC.

Figure 1 - Biplot-type dispersion scheme with circle of eigenvectors obtained by the analysis of two principal components (CP1 and CP2) established based on variables of purity (P), weight of a thousand seeds (WTS), germination (G), seedling emergence in the field (SEfield), seedling emergence in sand (SEsand), maximum flowering temperature (T+F), degrane (T+D) and harvest (T+H), accumulated rainfall on flowering (RF) and harvest (RH) in the evaluation of the physiological quality of 10 of *Brachiaria brizantha* cv. BRS 'Piatã' seed lots from different production fields



In principal component 2, among significant values (greater than 0.6), only seedling emergence in sand was inversely proportional to accumulated precipitation during flowering and harvesting, and presented a behavior similar to maximum temperature at harvesting. Therefore, accumulated precipitation over 500 and 137 mm in flowering and harvesting, respectively, would be unfavorable to vigor. Conversely, high maximum temperatures at harvesting would be favorable, according to the seedling emergence in sand test.

During the flowering season, the production sites showed similar rainfall levels between 534 and 654 mm. Only the counties of Palmeiras de Goiás - GO, Correntina - BA and Paraíso das Águas - MS diverged and showed lower rainfall volumes, with values of 298, 322 and 398 mm, respectively.

As the seeds stay on the soil until they are collected by sweep, the farmers harvested on days without rain. Otherwise, the operation of the harvesting machine is not possible. However, in the harvest months some sites showed higher rainfalls than others. In Santo Anastácio - SP, Dracena - SP and Jataí - GO were registered, respectively, 181, 167 and 137 mm of accumulated rainfall in the harvesting months (May to July). In this period, the other sites showed data of rainfall data under 83 mm.

For seeds of wide ranged crops, the occurrence of rain at harvesting periods spoil the physical and physiological quality of the seeds because of the metabolism increased and deterioration process (CARVALHO; NAKAGAWA, 2012). So, the seed companies will choose production regions that have periods of drought during the harvesting period.

The dispersion chart (Figure 1) shows the distribution of production fields in four different groups. Group 1 was composed of seeds produced in Correntina - BA and Paraíso das Águas - MS, which presented the highest mass of a thousand seeds, germination, seedling emergence in sand and field values, indicated by the eigenvectors of these variables closest to these production fields. This fact had already been verified by means comparison test (Tables 2 and 3).

Regarding the climatic conditions of these production fields, there was lower accumulated precipitation during flowering and harvesting periods, as was shown by the eigenvectors located in the opposite quadrant of the dispersion chart (Figure 1).

These results are in agreement with results obtained by Souza (2001), who reported favorable effects of a well defined dry season between May and September in Central Brazil and part of the Southeastern region on the harvest and quality of forage grass seeds.

Group 2 was composed of seeds produced in Tupaciguara - MG, which presented higher purity and germination percentages, indicated by eigenvectors close to this production field. For this production field, smaller average temperatures were observed at flowering, threshing and harvesting times, verified by eigenvectors located in the opposite quadrant of the dispersion chart. Stand out that this site showed good conditions to seeds production for this specie, because to lower temperatures.

Seeds produced in Santo Anastácio - SP, Dracena - SP, Jataí - GO and Costa Rica - MS composed group 3, with low vigor, according to seedling emergence in sand and field variables. The physical quality of seeds of these production fields evaluated by the mass of a thousand seeds was also lower. These facts can be verified by the eigenvectors positioned in the opposite quadrant of the dispersion chart. The greatest rainfall accumulations in the flowering and harvesting seasons, verified by eigenvectors in the same quadrant, were recorded in these production fields.

Precipitations during flowering are detrimental to the pollination of alogamous species, such as 'Piatã' grass. *B. brizantha* seeds are apomictic, that is, generated without fertilization, but require pollination stimulation to form the endosperm (MARCOS FILHO, 2016). Few studies report on climatic conditions in seed production; for 'Piatã', Silva *et al*. (2019b) shows that sites with maximum temperatures higher than 30 °C, mean values close to 25 °C, and rainfall less than 82 mm during harvest were favorable to the incidence of *Fusarium* spp. The incidence of *Bipolaris* sp. in the seeds of Piatã grass was favored by temperatures around 19 and 20 °C during the maturation phase. The highest incidence of *Exserohilum* sp. occurred at the sites in which the temperature during harvest was close to 20 °C and accumulated rainfall, between 167 and 181 mm.

Souza (2001) reported that rains in the harvesting period cause deterioration of tropical forage grass seeds that are on the ground and may lead to delays in harvest due to the time required for the drying of the area. Excess rainfall in the pre-harvest, in addition to accelerating metabolism and deterioration, favors the incidence of microorganisms, compromising the physiological potential of seeds (MARCOS FILHO, 2016).

Group 4 was composed of seeds produced in Palmeiras de Goiás - GO, São Desidério - BA and Unaí - MG, which presented the lowest germination and purity percentages, verified by eigenvectors positioned in the opposite quadrant of the dispersion chart. The highest maximum temperature values recorded during flowering, threshing and harvesting were verified in these production fields. Seeds produced by this group also presented lower mass of a thousand seeds and vigor verified by the seedling emergence in field and sand.

Regions with temperatures above 30 °C during maturation reduce the accumulation of carbohydrates in seeds and, consequently, reduce their physiological quality (MARCOS FILHO, 2016).

Based on these results, it could be inferred that the maximum temperature in the production field during flowering, threshing and harvesting and precipitation in the flowering and harvesting periods of the different production fields influenced the physiological potential and physical quality of seeds produced.

CONCLUSIONS

1. Production fields with temperatures above 30 °C during flowering, threshing and harvesting periods are related to the production of lower physical and physiological quality 'Piatã' grass seeds;
2. Sites with accumulated rainfall over 500 and 137 mm in the flowering and harvesting period, respectively, are unfavorable to seed vigor.

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